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Rice Culture in the Southern States

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RICE is the principal cash cereal crop grown on the prairies of southwestern Louisiana, southeastern Texas, and on the Grand Prairie of eastern Arkansas. The crop is grown on relatively level heavy soils that hold water well and that, with reasonable cost, can be prepared for irrigation and provided with fairly good surface drainage. About 42 million bushels are grown annually in the United States.

A dependable and adequate supply of fresh irrigation water is necessary for successful rice culture. This water is obtained from streams that pass through the prairies, or from wells.

The levees, which divide the field into subfields, should be well constructed on contours and of sufficient height to hold an average depth of 5 inches of water on the land.

Rice is sown between April 1 and May 15, usually with grain drills; but broadcast seeders also are used. Normally there is sufficient moisture in the seedbed to induce germination and to maintain seedling growth until the land is submerged.

The crop is promptly harvested when mature and is shocked in such a manner that the grain, while curing, is protected as much as possible from exposure to the sun and rain. The rice is threshed after it has cured in the shock from 10 days to 2 weeks. The threshed grain is stored on the farms or in public warehouses until sold to the rice mills, in which it is prepared for market.

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RICE CULTURE IN THE SOUTHERN STATES

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INTRODUCTION

RICE (*Oryza sativa* L.) is the principal energy food of a large part of the population of China, India, the Japanese Empire, Indo-China, Siam, the Dutch East Indies, the Philippine Islands, Malaya, and Madagascar. About 97 percent of the world's annual rice crop is produced in the Far East. The principal producing countries in the temperate regions are Italy, the United States, Spain, Brazil, and Egypt.

The per capita consumption of rice in the continental United States is about 6 pounds a year, whereas in India, Chosen, French Indo-China, Java, Madoera, and the Philippines it is over 200 pounds, and in Japan proper, Taiwan, and Siam, from 300 to 400 pounds.

HISTORY

Rice probably originated somewhere in the area extending from southern India to Cochin-China. Its cultivation appears to have spread from this region northeastward to China, possibly as early as 3,000 years before the Christian era, and more recently west and north through India to Iran (Persia), Arabia, Egypt, and ultimately to Europe.

Rice was introduced into the colony of South Carolina at or near Charleston, probably from Madagascar, about 1685. The acreage sown in South Carolina increased rapidly, and the crop soon moved

into North Carolina and Georgia. About 1718 it was introduced into Louisiana. In 1859, South Carolina, North Carolina, and Georgia produced about 90 percent of the rice grown in the United States, and South Carolina alone produced about 60 percent of that grown. Rice growing in the South Atlantic States was affected adversely by the Civil War, and production declined thereafter. About this time the rice acreage increased along the Mississippi River in Louisiana. However, the crop did not become very important in Louisiana until 1887, when it was determined that rice could be grown profitably by machine methods on the prairies in the southwestern part of the State. In 1889 Louisiana became, and still is, the leading State in rice production.

Upland or nonirrigated rice probably was grown to a small extent in Texas as early as 1863; however, the crop did not become of commercial importance on irrigated land until 1899, when some 8,500 acres were grown in the Beaumont district of Jefferson County, in southeastern Texas. The successful production of rice on the nearby prairies of southwestern Louisiana no doubt had a stimulating effect on the development of the industry in Texas.

In 1902 rice was grown on a limited scale on the Grand Prairie of Arkansas near Lonoke. In 1904 over 400 acres were grown, and commercial production began the following year.

In California the first commercial rice crop was grown near Biggs, in the Sacramento Valley, in 1912.

The first crop of rice in the upper Mississippi Valley was grown near Elsberry, Mo., in 1923. The high yields and high prices obtained for this crop resulted in a rapid extension of the rice acreage in the Elsberry district, and by 1928 over 10,000 acres were sown. In this district, however, the decline in the rice acreage following 1928 was even more rapid than the increase had been, and by 1930 practically no commercial rice was grown. The sudden collapse of the new industry was largely brought about by a decline in yields and the poorer quality of the rice, due to (1) a shortage of irrigation water and facilities for irrigation; (2) poorly constructed canal and field levees; (3) inadequate surface drainage; and (4) failure to rotate rice with other crops. Practically no commercial rice is now grown in Missouri, but relatively high yields have been obtained in the cooperative experiments at Elsberry Field, Elsberry, Mo.

The commercial rice crop of the United States is now grown almost entirely in the States of Arkansas, California, Louisiana, and Texas.

RICE-PRODUCING SECTIONS

The three principal rice-producing sections in the United States are: (1) The broad level prairies of southwestern Louisiana and southeastern Texas. Irrigation water for this section is largely pumped from sluggish streams or bayous, which provide natural drainage for the prairies; however, wells also provide water for irrigation. This is the most important rice-producing section of the United States.

(2) The Grand Prairie section of eastern Arkansas. Irrigation water for this section is largely pumped from wells.

(3) The Sacramento and San Joaquin Valleys of California. In these valleys irrigation water is obtained by diversion or pumps, largely from the Feather and Sacramento Rivers.

The methods of production in California differ materially from those used in the Southern States, and since Farmers' Bulletin 1240, How to Grow Rice in the Sacramento Valley, is available, which deals with the methods of production in California, this bulletin, except for information regarding the importance of the rice crop, is confined largely to the conditions under which rice is grown in the Southern States and the methods of production used there.

IMPORTANCE OF THE RICE CROP

In the United States the acreage on which rice crops can be grown successfully is much more limited than the acreage adapted to other cereals. Rice, however, is well adapted to certain sections of Arkansas, California, Louisiana, and Texas on which other cereals cannot be grown successfully, owing largely to excessive moisture and high temperatures. In many counties and parishes of these four States rice is the principal cash crop grown (fig. 1).

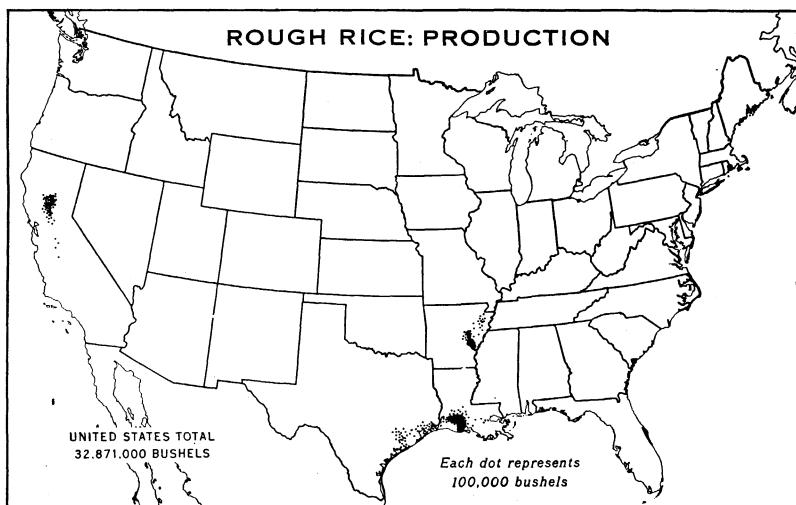


FIGURE 1.—Rice production in 1935. Each dot represents 100,000 bushels.

Louisiana produces about 40 percent of the commercial rice crop grown in the United States, and Arkansas, Texas, and California produce about 20 percent each.

REQUIREMENTS OF THE CROP

CLIMATE

In the United States the production of satisfactory rice crops is dependent upon (1) high temperatures, especially relatively high mean temperatures, during the growing season; (2) a dependable supply of fresh water for irrigation; (3) soils that are comparatively level and hold water well because of a tight soil or subsoil through which loss by seepage is small; and (4) good surface drainage.

These conditions prevail to a large extent on the coastal prairies of southwestern Louisiana and southeastern Texas and on the Grand Prairie of Arkansas. In these sections the summers are hot and

sultry, and the daily maximum temperatures usually range from 90° to 100° F. or above, and the mean temperatures in late spring and early fall are about 70° and in summer about 82° or above. The average annual precipitation ranges from about 36 to 56 inches and is well distributed during the growing season. For this reason less irrigation water is required to produce a crop than if the summer rainfall were low.

SOILS

Rice can be grown on all types of soils, but the crop normally is grown only on medium to heavy soils, which are more economical in the use of water and, when drained, support harvesting machinery better than do lighter soils. In Louisiana and Arkansas a good deal of rice is grown on Crowley silt loam, which holds water well. This soil is rather heavy and compact and when plowed wet is likely to puddle. Rice is also grown in these States on lighter soils underlain by relatively impervious subsoils.

In southeastern Texas, Lake Charles clay is a typical rice soil. It is rather plastic and sticky when wet and is more difficult to cultivate than Crowley silt loam. Lake Charles clay and other soils on which rice is grown in Texas may puddle and then bake on drying, if plowed wet. A better seedbed is obtained if plowing is done when puddling does not occur.

The soils on which rice is grown in the Southern States usually are deficient in organic matter.

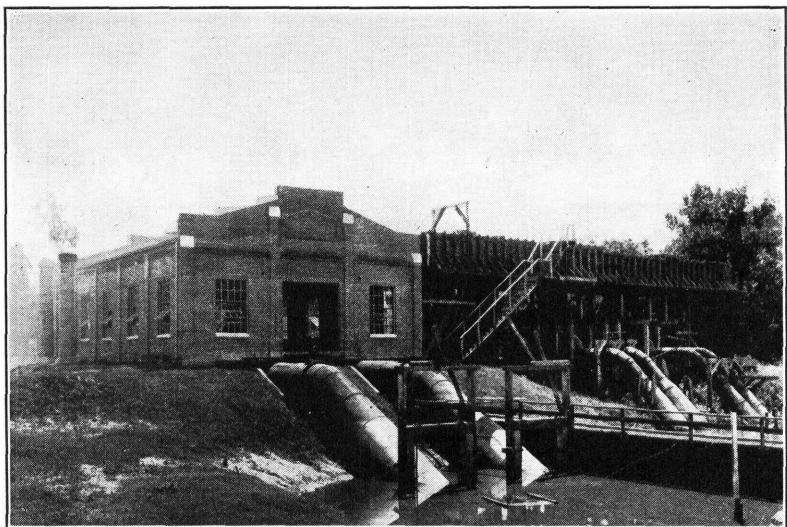


FIGURE 2.—Intakes for modern irrigation pumps.

SOURCES OF IRRIGATION WATER

Irrigation water for rice production on the prairies of Louisiana and Texas is obtained largely from the sluggish streams that pass through the prairies en route to the Gulf of Mexico. The water is lifted from the streams by pumps and is distributed in surface canals by privately owned companies (figs. 2 and 3). In this region, how-

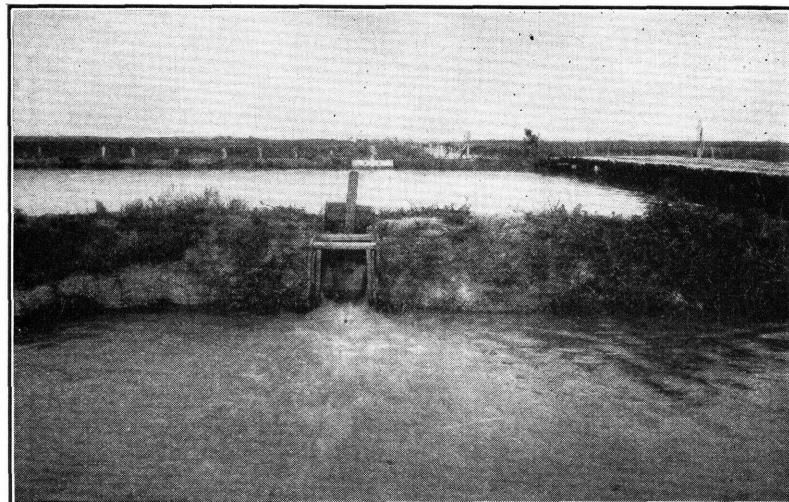


FIGURE 3.—A floodgate through which water passes from the main irrigation canal into smaller canals and then into the fields.

ever, considerable irrigation water is also obtained from wells. In some wells near the Gulf, water stands near the surface of the ground, but away from the Gulf it is sometimes 35 or 40 feet below the surface. There are sufficient wells in this region to irrigate, if necessary, from 30 to 40 percent of the rice acreage in Louisiana and probably from 15 to 20 percent of that sown to rice in Texas (fig. 4). The wells are owned by the farmers, and while most of them are operated each year others are used only in case of a shortage of fresh water in the canals. It requires about 48 inches of water to produce a crop

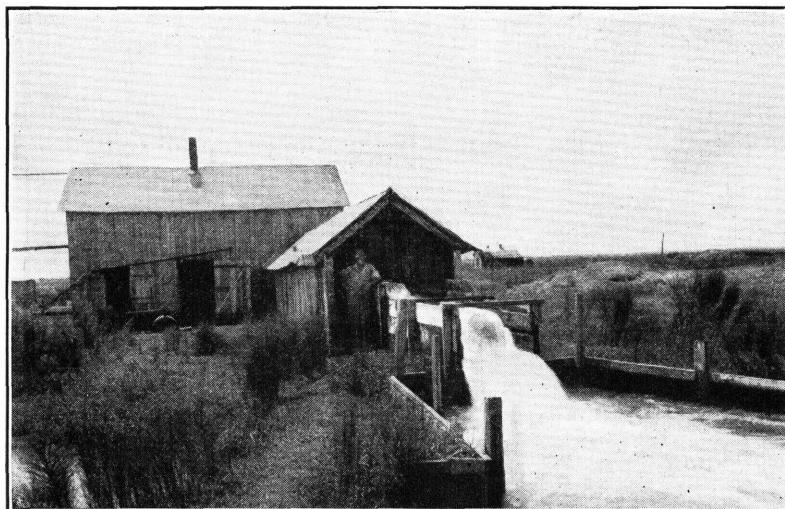


FIGURE 4.—Water being discharged from a well.

in this region, of which about 20 inches are supplied by rainfall during the growing season. The charge for water supplied by canal companies varies from year to year, but ranges from \$6 to \$9 per acre per season.

In Arkansas most of the irrigation water is obtained from wells owned by individual farmers. The water level ranges from 25 to 60 feet below the surface of the ground. The capacity of the pumps used depends upon the acreage to be irrigated and the lift. The minimum capacity of the pump should not be less than 5.6 gallons per minute per acre. The cost of pumping water usually ranges from \$6 to \$10 per acre per season. It requires from 24 to 30 inches of water to produce a rice crop on normal soils of the Grand Prairie, of which about 6 inches is supplied by rain during the growing season.

PREPARATION OF LAND FOR IRRIGATION

Most of the land on which rice is grown in the Southern States is comparatively level, with a gentle slope toward drainage channels. The preparation of such lands for irrigation is usually not very expensive. A competent surveyor should be employed to locate the supply and drainage ditches and the field levees. The improper location of ditches and levees may cause serious losses, owing to faulty irrigation and poor drainage. The irrigation ditches should be large enough to supply ample water promptly when needed, and the drainage ditches should likewise have sufficient capacity to dispose of the water promptly when desired. The levees that divide the field into subfields should be permanently located on contour lines. They should be spaced so that the water in the subfields can be held at an average depth of 4 to 6 inches. The levees should have gently sloping sides and be high enough to hold an average depth of 6 inches of water on subfields without overflowing into the next lower subfield (figs. 5 and 6). Farm machinery can pass readily over levees of this type without damage to them or the machinery. Sloping levees reduce the cost of seedbed preparation, of seeding, and of harvesting, for each field can be worked as a unit. Levees of this type are also seeded and often produce considerable rice, thereby reducing the growth of weeds. If high, narrow levees are used, each subfield usually must be prepared for seeding, seeded, and harvested separately.

Compact levees reduce seepage. Levees should be constructed and repaired, if possible, during the winter months, so that they will have time to settle before irrigation begins. All newly constructed levees settle considerably and should be built nearly twice as high as is necessary to hold the water at the desired level. Well-constructed levees facilitate irrigation and make it unnecessary to do much expensive hand-shoveling when the fields are submerged.

Irrigation water normally is delivered by ditches, canals, or pumps to the highest subfields in a field, and it passes into successively lower subfields through openings in the levees. The openings in the levees are closed when the desired depth of water is attained in the field. Some fluctuation in the depth of water held on

rice fields is almost unavoidable, owing to variations in the irrigation water supply and in rainfall.



FIGURE 5.—Constructing a levee with a disk plow.

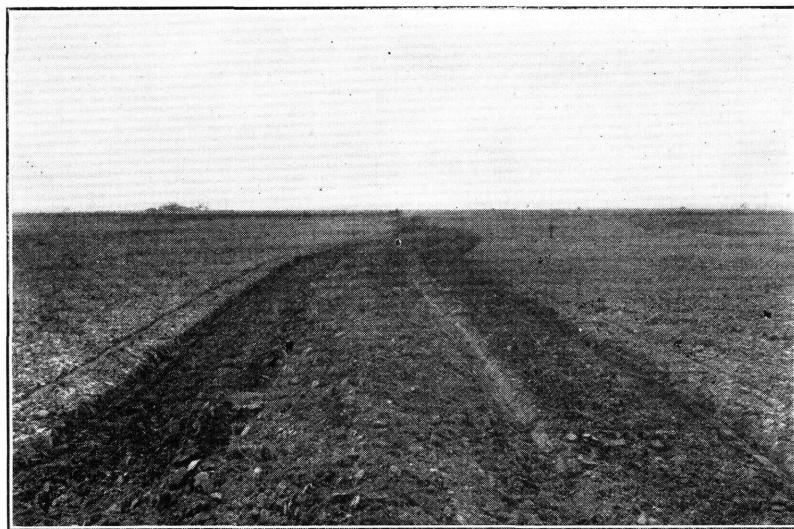


FIGURE 6.—A levee partially constructed with a disk plow.

ROTATION

Rice is grown under conditions that make it difficult to follow a definite system of crop rotation. In order to grow cultivated crops conveniently in rotation with rice the levees usually are broken down

and then reconstructed for the following rice crop, and this involves considerable expense. Furthermore, cultivated crops often are not profitable.

Rice, however, is not grown continuously on the same land. The most common practice in Louisiana and Texas is to grow one or more rice crops, then pasture the land for 1 to 3 years before using it for rice again. The land is materially improved in physical condition by the accumulation of organic matter on the surface during the period it is grazed. Rice soils, as a rule, are deficient in organic matter because the high temperatures and available moisture lead to a rapid decomposition of organic materials incorporated in the soil. For this reason a rotation of rice and pasture appears to be the best cropping system (fig. 7).

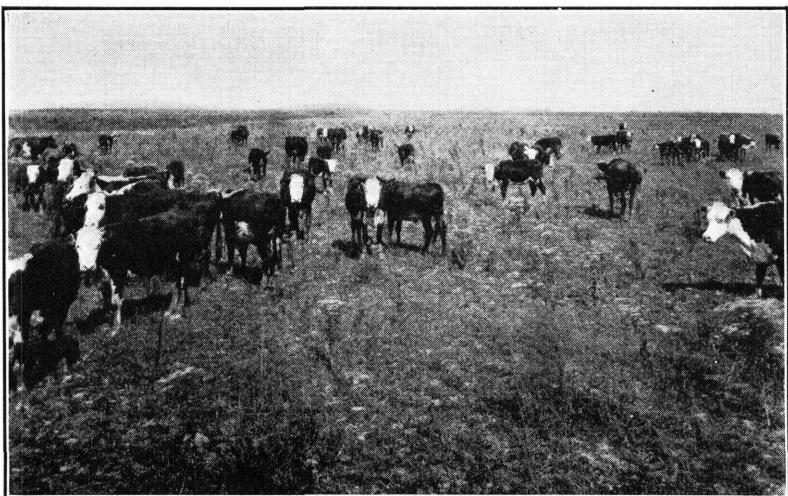


FIGURE 7.—Cattle grazing on rice-stubble land.

Rice is also grown in Louisiana and Texas in rotation with clean fallow, cotton, soybeans, corn, and green-manure crops. Fallowing is a more common practice than the growing of crops.

In Arkansas only a small portion of the resting riceland is pastured. Much of it is simply allowed to lie idle; the remainder is planted to soybeans, is fallowed, or is planted to corn, cotton, or green-manure crops, which rank in importance in the order listed.

PREPARATION OF THE SEEDBED

In the preparation of a seedbed for rice the aim should be to destroy weeds and obtain a mellow, firm surface layer in which the rice can be sown to the desired depth under conditions that are favorable for quick germination and normal seedling development. The land should be plowed 4 to 6 inches deep in the fall, winter, or spring (fig. 8). Fall- and winter-plowed land is normally left until the following spring. If the land is reasonably well drained, the frost and winter precipitation mellow the plowed soil, and usually

by spring a good seedbed can be prepared by disking, harrowing, and floating (fig. 9). On poorly drained land more difficulty is experienced in preparing a suitable seedbed, and replowing may be



FIGURE 8.—Plowing land for rice.

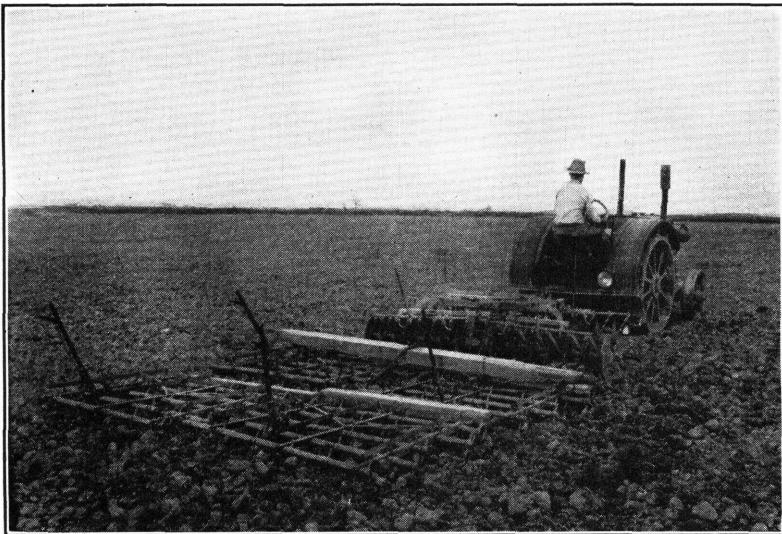


FIGURE 9.—Preparing a seedbed for rice.

necessary. Rice stubble and weed growth plowed under in the fall and winter decompose readily, thus facilitating the preparation of a good seedbed. The land may be floated before disking, to break clods and to fill in holes. The number of times it will be necessary

to disk and harrow depends upon the drainage and the condition of the soil.

Spring-plowed land ordinarily should be disked and harrowed immediately after plowing, to prevent baking and subsequent difficulty in seedbed preparation. Heavy soils, when spring-plowed, usually require more subsequent tillage to obtain a good seedbed than when plowed in the winter, but light soils are prepared easily after either winter or spring plowing.

In Louisiana and Texas early fall and winter plowing of riceland is common, but in Arkansas most of the land is spring-plowed. In Louisiana the land may be disked in January and February, if weather conditions are favorable.

In a good seedbed the surface soil is reduced to a mellow, firm condition, moisture is held near the surface, and germination usually occurs after seeding without requiring irrigation.

VARIETIES NOW GROWN

In the principal rice-producing countries of the world, varieties are often classified as lowland (irrigated) and upland (nonirrigated). Lowland (irrigated) varieties can be grown without irrigation, but under such conditions are less productive than when grown with irrigation. Upland (nonirrigated) varieties, when grown under irrigation, usually are more productive than when grown without irrigation, but are less productive than the better lowland varieties. The words "lowland" and "upland" do not refer especially to elevation, for lowland varieties are grown on terraced hillsides as well as on lowlands and upland varieties may be grown without irrigation on uplands and lowlands.

In the commercial rice-producing sections of the Southern States only the lowland or irrigated varieties are grown. The varieties grown include short-, medium-, and long-grain types, which vary in height from 36 to 58 inches at maturity. The average length of the kernel (hulled rice) of the short-grain rice is about 5.5 millimeters, that of the medium grain about 6.6 millimeters, and that of the long grain about 7 to 8 millimeters (fig. 10). One millimeter is equal to about one twenty-fifth of an inch.

When sown between April 15 and May 15, the varieties grown in the Southern States may be classed as early, midseason, and late. The early-maturing varieties require about 120 to 129 days from seeding to maturity, the midseason varieties about 130 to 139 days, and the late-maturing varieties 140 days or more.

The number of days required from seeding to maturity varies with the date of seeding. Rice sown relatively early in the spring requires a longer time to mature and usually produces higher yields than that sown late. All varieties, however, do not have the same capacity to shorten the length of the growing period when sown late. For example, at Crowley, La., Blue Rose, when sown March 15, matures in about 189 days; but when it is sown May 15 it matures in about 135 days, or a difference of 54 days, whereas Early Prolific, sown on the same dates, matures in 141 and 122 days, respectively, or a difference of only 19 days.

Varieties that materially lengthen or shorten their growing periods when sown from early to late in the spring include Blue Rose,

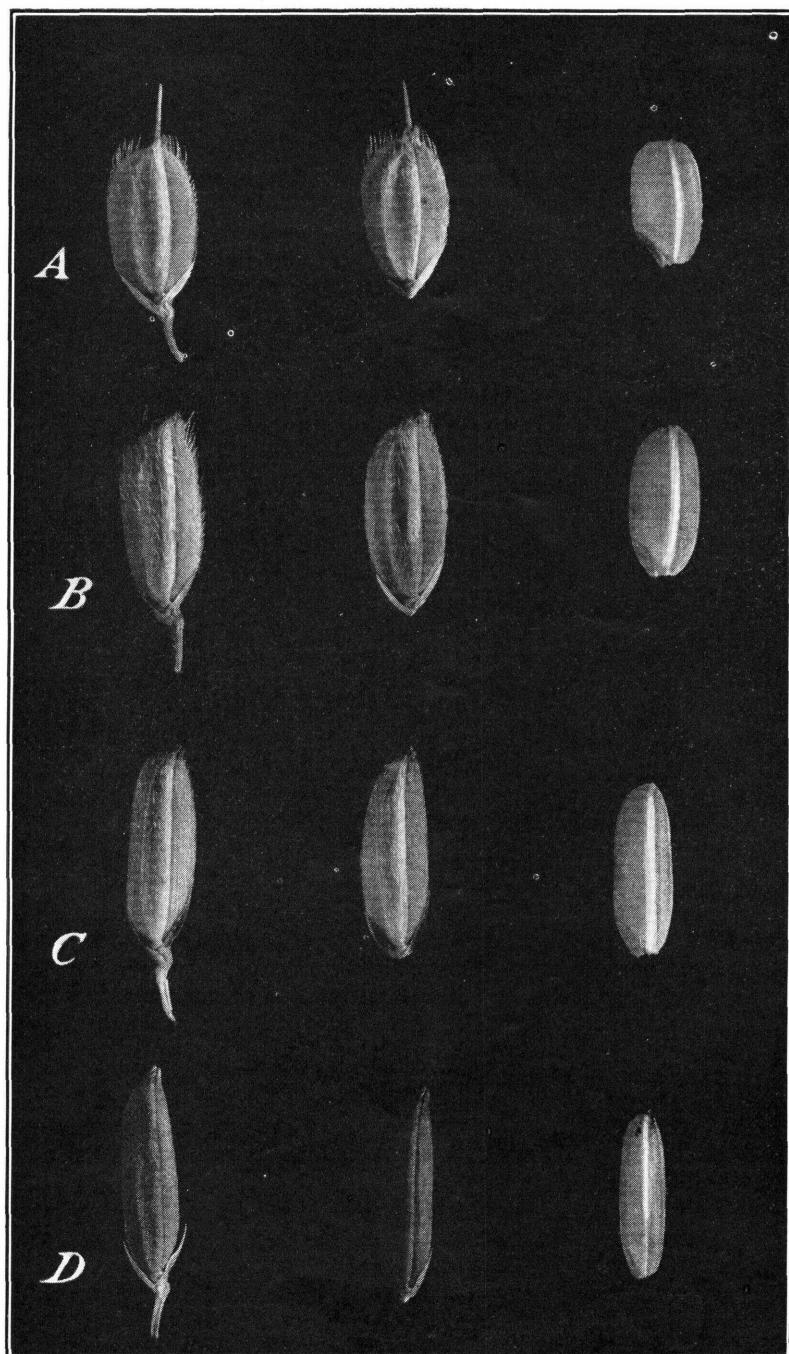


FIGURE 10.—Spikelet, seed, and kernel of (A) Caloro, short grain; (B) Blue Rose, medium grain; (C) Fortuna, long grain; (D) Rexoro, long slender grain rice.

Wataribune, Acadia, Caloro, and Honduras. Varieties that show much less variation in the length of the growing period when sown from early to late in the spring include Early Prolific, Fortuna, Delitus, Rexoro, Nira, and Iola.

Varieties, such as Blue Rose, that have a tendency to mature at nearly the same date regardless of the date of seeding are not well suited for growing on a large acreage, because the entire crop is likely to be ready for harvest at about the same time. Such varieties, however, are well suited for late seeding. Varieties, such as Early Prolific, Rexoro, etc., can be used to advantage on large acreages, because they mature relatively early if sown early and later if sown late. Hence, the harvest period can be extended over a longer period by seeding at different times. These varieties, however, are not well suited for late seeding.

SHORT-GRAIN VARIETIES

The short-grain rice varieties grown in the Southern States are of Japanese origin and are fairly well adapted for growing on the prairies of the South as well as in California. They are hardy and produce relatively high field yields of good milling quality. Years ago these characteristics tended to make them popular with both farmers and millers. Now, however, medium- and long-grain varieties are preferred by the growers and the consuming public.

The leading short-grain rices grown are Wataribune, Acadia, and Shinriki, which, when sown during the normal seeding period, are late maturing, and Caloro, an early or midseason variety. Only a small part of the total commercial acreage in the three Southern States, however, is sown to this type of rice. During the 3-year period (1933-35)¹ only 0.1 percent of the rice produced in Louisiana consisted of short-grain varieties, but in the same period 2.30 percent of that produced in Texas and 6.30 percent of that produced in Arkansas consisted of the short-grain rices.

The seeds of Wataribune, Acadia, Shinriki, and Caloro are short and broad, and the hull is light yellow (straw) in color. Wataribune, Acadia, and Caloro are partly awned (bearded), but the awns are comparatively short and usually are broken off in threshing. The leaves of these short-grain varieties are narrow, and the stalks are relatively small and pliable. They tiller freely and, when grown on rich land, produce heavy panicles, the weight of which may cause the plants to lodge. They do not shatter easily. The stalks and leaves of the short-grain varieties often are fairly green when the crop is mature.

MEDIUM-GRAIN VARIETIES

Most of the commercial rice produced in Louisiana, Texas, and Arkansas consists of the medium-grain varieties Blue Rose and Early Prolific. The seeds of these varieties are not so long as those of Edith or so short as those of Caloro. They usually yield and mill well and for this reason are popular with both rice growers and millers. Blue Rose and Early Prolific have relatively stiff straw, fairly wide leaves, and when grown on reasonably fertile land tiller freely and yield well. When sown during the normal seeding period,

¹ The information on the acreage and production of varieties is based on annual data compiled by the Rice Millers Association, New Orleans, La.

Blue Rose is a late-maturing variety, and Early Prolific, as the name indicates, is early maturing. Both varieties are susceptible to diseases and for this reason probably are not now so productive in the South as they once were. In the 3-year period 1933-35, 92 percent of the rice produced in Arkansas, 91 percent of that in Louisiana, and 68 percent of that in Texas consisted of Blue Rose and Early Prolific.

LONG-GRAIN VARIETIES

Long-grain rice varieties are not so extensively grown in the Southern States as are the medium-grain varieties. This probably is because in the past the principal long-grain varieties grown did not yield so well in the field or in milling as do the medium-grain varieties. Owing to the shape of the kernels, long-grain rices are more likely to be broken in milling than are the medium- and short-grain varieties. Long-grain varieties, however, often have commanded a premium over medium- and short-grain rices in the rough- and clean-rice markets. This increase in value of the rough and clean rice has tended to make up for the loss resulting from lower field and mill yields when compared with medium- and short-grain varieties.

Honduras, an early-maturing, long-grain variety, was extensively grown for many years in the Southern States. Owing to the fact that it is susceptible to disease and produces relatively low yields on old land, it was largely replaced by the long-grain, early-maturing Edith and Lady Wright varieties, which are now being replaced by the later maturing Fortuna, Rexoro, and Nira varieties. These three, which have only recently been released for commercial growing, produce higher field yields than the others mentioned, are more resistant to disease, and are also of better table quality.

In 1936, 4.27, 7.84, and 2.89 percent of the rough rice produced in Louisiana consisted of Fortuna, Rexoro, and Nira, and these varieties made up 6.59, 11.08, and 5.56 percent, respectively, of the rice produced in Texas. They are vigorous, have stiff straw and wide leaves, yield well, mill well for rices of this type, and are of good table quality. Owing to late maturity, when sown during the usual seeding period, they are best suited for growing in Louisiana and Texas, whereas Honduras, Edith, and Lady Wright can be grown equally well in Arkansas. If sown early, Fortuna and Nira also could probably be grown successfully in Arkansas. Fortuna, Rexoro, and Nira grow tall enough to bind well, tiller quite freely, and are easily threshed even though they are rather leafy. In order to reduce shattering, these varieties should not be harvested until fully mature.

SEED AND SEEDING

IMPORTANCE OF GOOD SEED

Good seed rice should be well matured and free from red rice, immature, hulled or broken seed, seed of other varieties, and weed seeds. The seed should be cleaned well to remove hulls, trash, weed seeds, and immature seeds. Mixtures of other varieties differing in kernel size or maturity are particularly objectionable. Uniformity in ripening and in kernel size are more important in rice than in wheat because the value of rough rice is based largely on the percentage of whole kernels obtained in milling, whereas wheat is ground into flour.

Seed containing red rice (rice with red kernel coats) should be avoided because the red grains spoil the appearance of the milled rice. Seed of low germination may result in uneven stands, uneven ripening, and often in lower field yields of poor milling quality.

METHOD OF SEEDING

Rice usually is sown with a grain drill, but broadcast seeders also are used. In Arkansas most of the rice is broadcast. Of the two methods, drilling is preferred because it places the seed at a uniform depth under conditions that are more favorable for uniform germination (fig. 11). Less seed is required to obtain maximum stands of



FIGURE 11.—Seeding rice with a 12-hole grain drill.

drilled rice than of broadcast rice, but drilling is more expensive. Rice often is broadcast on poorly prepared rough seedbeds in Louisiana and Texas. If rice is drilled too deep, the seedlings may have difficulty in emerging, especially if a crust forms on the soil surface following rains.

TIME OF SEEDING

Rice usually is sown in the Southern States from April 1 to May 15, but some seeding is done in March if conditions are favorable. Rice germinates more quickly when sown late in the spring, when temperatures are high, than when sown early. Seed of early sown rice is more subject to rotting because of the lower temperatures and less favorable conditions for quick germination and rapid growth. Under such conditions poor stands may be obtained. Late seeding also has an advantage in that the weeds that have started growth can be killed by cultivation prior to seeding. Results from date-of-seeding experiments indicate that there is a comparatively long period in the South during which rice can be sown and still produce satisfactory yields. It is possible and, in some cases advisable, to vary the date of seeding of certain varieties, so that the harvest can be extended over a longer period.

RATE OF SEEDING

Rate-of-seeding experiments with drilled rice, under very favorable conditions, indicate that 80 pounds of seed per acre usually is sufficient to give good stands and that the yields are seldom materially increased and may be reduced if more than 80 pounds an acre is sown. Under ordinary conditions, 90 to 100 pounds of recleaned viable seed sown with a drill or 125 to 150 pounds sown broadcast is sufficient to give good stands. The rate of seeding should be sufficiently high to produce stands that are thick enough to check weed growth and also to prevent excessive tillering, which might result in irregular ripening and reduced yields of inferior quality. Less seed is required when rice is sown late than when it is sown early in the spring, for conditions are more favorable for germination late in the season. Many other factors, such as seed quality, condition of the seedbed, fertility of the soil, and the variety enter into the determination of the proper rate of seeding.

DEPTH OF SEEDING

On good seedbeds rice should be sown 1 to 2 inches deep. Usually there is less danger from rotting from shallow than from deep seeding, especially if it is necessary to flush (irrigate) the land after seeding to induce germination. Rice can be sown deeper with safety on light soils than on heavy soils. Shallow seeding is preferable to deep seeding on a rough seedbed or a fine mellow seedbed that is likely to crust following rains. Surface crusts, when they form, may be broken up by a light harrowing or by irrigation, to permit the emergence of the seedlings.

FERTILIZERS

Prairie rice soils often are deficient in phosphorus as well as in organic matter. Rice, like other crops, cannot be grown profitably on soil so deficient in nutrients that they must all be supplied as fertilizers. The best fertilizer treatment can usually be determined by tests conducted under local conditions. The results of fertilizer experiments in which nitrogen, phosphorus, and potash have been applied singly and in combinations at seeding time, at the rice experiment stations in the South, have not as a rule shown consistent or marked increases in yields.

Nitrogenous fertilizers may produce a more vigorous growth of stalks and leaves under certain conditions. Heavy applications may result in lodging and in plants that are more susceptible to diseases. Usually the soil nitrogen can be maintained by turning under organic matter, such as rice stubble, green-manure crops, weeds, and other organic materials. In soils well supplied with organic matter, the decomposition of this material under submerged conditions usually liberates sufficient nitrogen as ammonia to meet the requirements of rice plants.

Under certain conditions ammonium sulphate may be applied to advantage. Applications of from 150 to 200 pounds of ammonium sulphate to the soil at seeding time at Texas Agricultural Substation No. 4, Beaumont, have materially increased the yields of rice.

The rice soils of the prairies often are deficient in phosphorus and nitrogen, and the lack of these elements rather than lack of potash is likely to be a limiting factor in rice production. The fertilizer most

commonly used contains superphosphate principally and is applied at seeding time at the rate of 150 to 200 pounds per acre. Under certain conditions, however, fertilizers containing phosphorus may actually decrease the yields of rice, as they increase weed growth.

The relative effect of the same fertilizer applied at different times has been studied. In Texas yields have been essentially the same whether fertilizers were applied at seeding time or 30 days later. In Arkansas, however, the largest increases in yields from fertilizers have been obtained from applications 6 to 8 weeks after seeding.

In each of the three Southern States nitrogenous and phosphoric fertilizers may be used to advantage under certain conditions, but environment, soil, and drainage are so varied that specific recommendations for all conditions are not advisable. Local tests should



FIGURE 12.—A submerged field of young rice.

determine whether applications of nitrogen or phosphorus or both are profitable.

Probably the best way to insure high yields is to maintain an adequate supply of organic matter in the soil. The decomposition of organic matter will assist in liberating the plant-food elements already in the soil, improve the physical texture of the soil, and tend to provide for proper aeration of the roots by creating conditions favorable for the percolation of water into the soil.

IRRIGATION

Rice is grown in essentially the same way as other small grains, except that the land on which the crop is grown is submerged for 60 to 90 days or more during the growing season. Normally, when young rice plants reach a height of 6 to 8 inches the land is submerged to a depth of 1 to 2 inches (fig. 12). As the plants grow taller, the depth of water is gradually increased until it reaches 4 to

6 inches (fig. 13). During the remainder of the growing season, or until the land is drained prior to harvesting, except for special reasons, the water should be held on the land at a constant depth of about 5 inches. To maintain a constant depth of submergence, water must be applied from time to time to replace that lost by evaporation, transpiration, and seepage.

It is normally not necessary to flush the land to germinate the seed. In case it is necessary to irrigate for this purpose, however, the land should be drained promptly thereafter; otherwise the seed is likely to rot. From 24 to 48 inches of water is normally required to produce a rice crop, and of this amount from 6 to 20 inches is supplied by rainfall during the growing season.



FIGURE 13.—A field of rice 6 to 8 weeks after submerging the land.

DRAINAGE

The fact that rice is grown for several months on submerged land does not mean that good surface drainage is not essential. Good surface drainage is as necessary for successful rice culture as is a dependable supply of fresh irrigation water. Without good drainage it is difficult to prepare satisfactory seedbeds, to obtain good stands, and to produce satisfactory crops. Also the fields must be drained and dried prior to the full maturity and harvesting of the crop. Unless land is fairly well drained it is difficult to dry it sufficiently before harvest so that it will support tractors, binders, and other machinery used in harvesting operations. Harvesting costs on poorly drained land often are much higher than on well-drained land. The loss in harvesting is also greater since it is practically impossible to operate the harvesting machinery so as to save the entire crop.

Usually the land should be drained when the rice is fully headed and the heads are turned down and ripening in the upper portions. This ordinarily is about 2 weeks before the crop is mature.

HARVESTING

Rice should be harvested when the kernels in the lower portion of the heads are in the hard-dough stage. At this time the kernels in the upper portions of the heads are fully developed, ripe, and free from chalk and opaque spots, and should mill well. At this stage of development (fig. 14) the standing rice grain usually contains from 23 to 28 percent of moisture. Rice harvested before it reaches this stage of maturity is likely to have a relatively high percentage of chalky, lightweight kernels, which do not mill well. If the rice is harvested after this stage, the loss in some varieties from shattering

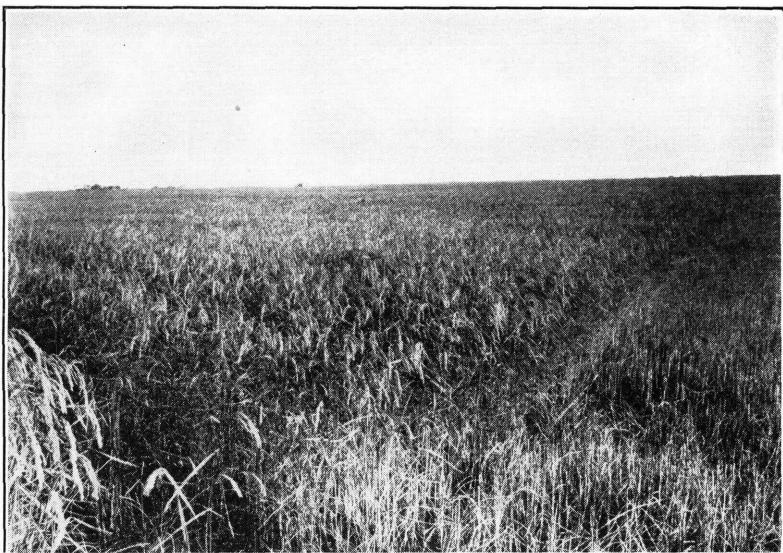


FIGURE 14.—A field of mature rice ready for harvesting.

may be increased, and owing to the probability of checking or cracking of the kernels the mill yield of unbroken rice is also likely to be reduced. Rice usually is harvested with grain binders drawn by tractors, mules, or horses (fig. 15).

Harvesting rice by the windrow or direct combining methods often is hampered in the South by weather hazards and by difficulty in pulling the machines across levees and low wet spots. Harvesting by these methods has thus far been only partially successful.

There is a relatively small district along the Mississippi River and Bayou Teche in Louisiana where rice is harvested with hand sickles, cured on the stubble, and tied by hand into bundles. It usually is placed in small stacks, but often is threshed immediately after being tied. A brief discussion of the practices followed in growing rice along the Mississippi River and in the Bayou Teche area is given on pages 21 to 23.

SHOCKING

Rice harvested with a binder should be shocked promptly, and in such a manner that the grain, while curing, is protected from rain and sun as much as possible. Excessive moisture interferes with

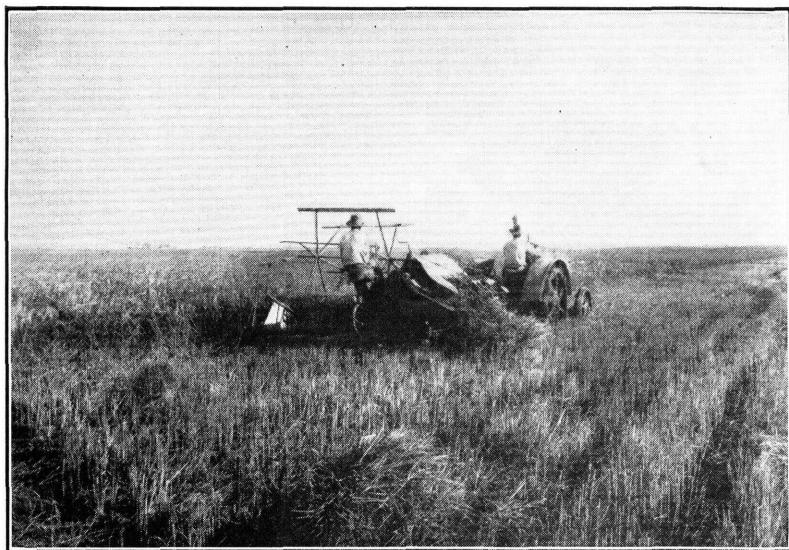


FIGURE 15.—Cutting rice with a grain binder.

proper hardening, and alternate drying and wetting may result in checking of the kernels. Careless shocking may thus result in rice of inferior milling quality and low price. The market value of rough rice depends very largely upon the percentage of head (whole) rice obtained in milling.

Rice cures well in shocks that are properly capped and provide for a free circulation of air. Usually from 9 to 12 bundles are placed in a shock, 1 or 2 of which are used as a cap. If the straw in the bundles is wet or too green, fewer bundles are placed in a shock (fig. 16).

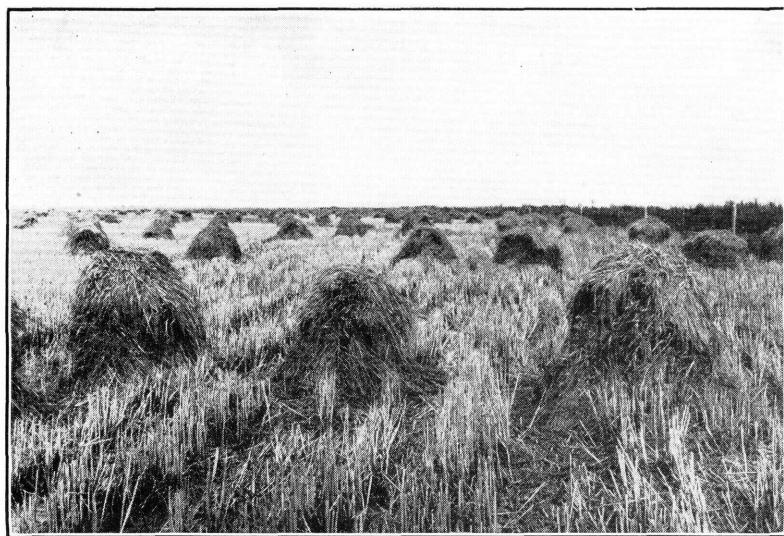


FIGURE 16.—A field of rice in the shock.

THRESHING

The rice is threshed after it has cured in the shock from 10 days to 2 weeks (fig. 17). The threshed grain is stored on the farms or in

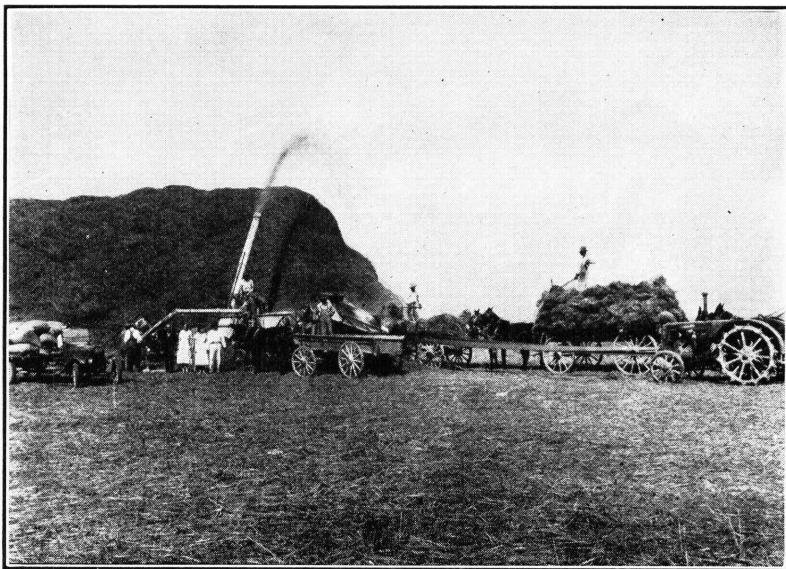


FIGURE 17.—Threshing rice.



FIGURE 18.—Trucks loaded with rough rice at a warehouse.

public warehouses (fig. 18) until sold to rice mills, in which it is prepared for market. The straw should be thoroughly dry and the

rice hard. Even well-dried rice is difficult to thresh when exposed to dew, high humidity, or rain at the time of threshing. Often shocks are spread to dry for a few hours before threshing operations begin. In threshing damp rice there often is a loss of grain due to poor separation. It is difficult to store damp rice without its spoiling. In threshing, an effort should be made to prevent cracking of the grain, because this lowers the milling quality of the rough rice. It is self-evident that threshers should be thoroughly cleaned when changing from one farm to another and from one variety to another, in order to prevent mixtures and also to prevent the spread of noxious weed seeds.

COST OF PRODUCTION

The cost of producing a crop of rice varies from year to year, owing to fluctuations in the cost of labor, power, water, seed, interest rates on investment, depreciation, yields per acre, and other items. The cost of production often ranges from about \$35 to \$50 per acre.

MISSISSIPPI RIVER AND BAYOU TECHE DISTRICTS

Each year several thousand acres of rice are grown along the Mississippi River and in the Bayou Teche district of Louisiana. The methods of production used in these areas are a combination of modern and earlier practices and are briefly discussed below.

Rice probably was first brought into Louisiana by the Frenchmen led by Bienville, who founded the city of New Orleans in 1718. Rice growing gradually extended into the parishes north of New Orleans, and its cultivation by the majority of planters up to the Civil War was for domestic use. Before the Civil War Plaquemines Parish produced about two-thirds of the rice grown in the State, but after the war it soon lost its rank, owing to the rapid increase in the rice acreage on hitherto idle lands, on former sugar plantations, and on the lowlands. It is estimated that in the 5-year period 1932-36 about 12,900 acres were sown annually to rice in the Mississippi River district.

The alluvial and "buckshot" soils adjacent to the Mississippi River are well suited for rice culture. The buckshot soil is dark in color and contains considerable clay. The river soils are more porous than the prairie soils and hence require more water to produce a crop. The land along the river usually slopes gradually from the river to the swamps, but in some places the slope is more abrupt, and in growing rice the levees must be placed rather close together. Nearly all the river land on which rice is grown has previously been divided by drainage ditches into long narrow strips, which extend from the river to the swamps. In growing rice these strips of land are divided into smaller checks by levees constructed at right angles to the drainage ditches.

In this district the water used in the irrigation of rice is siphoned from the Mississippi River. When the level of the water is high, the water is siphoned automatically over the levees, but when the water is low it is pumped either directly into the siphons or into small ponds on the riverbank, from which it is siphoned over the levees.

In some years the river is so low that the cost of pumping is prohibitive, and the crop is injured from lack of moisture unless heavy showers occur.

The river rice crop is grown, largely by sugarcane planters, on land that has produced several crops of sugarcane or corn or on abandoned weed-infested plantations on which two or more consecutive crops may be grown. The land usually is plowed in the winter, and in the spring the seedbed is prepared by disking and harrowing.

The same varieties are grown in the river sections as on the prairies, but the proportion of early maturing varieties probably is larger. The rice is sown with endgate seeders at the rate of 120 to 150 pounds per acre and covered with a harrow. Seeding often begins the latter part of February. The fields, with few exceptions,



FIGURE 19.—Cutting rice by hand along the Mississippi River.

are irrigated and drained after seeding, to induce prompt germination and obtain good stands. After the seedlings emerge, the method of irrigation is essentially the same as on the prairies.

The crop is cut with hand sickles (fig. 19) and allowed to cure on the stubble for about 24 hours before it is tied into sheaves and placed in small stacks. The sheaves are taken from the stacks to the thresher, which is usually housed under a shed. Under favorable conditions, the crop is often threshed as soon as it is tied into sheaves. The threshed rice usually is shipped to the mills immediately by water or rail.

In the river district, weeds, which grow abundantly, must be destroyed either by hand-pulling or by mowing. It is sometimes necessary to handweed the fields two or three times. When the weeds are too numerous to pull by hand, the water on the fields is lowered, and the rice and weeds are mowed with a scythe at a height

that does not injure the rice. After the mowing, the water is raised and the rice plants recover, but the weeds do not.

The most objectionable weeds are the tall indigo (*Sesbania macrocarpa*), Mexican weed (*Caperonia palustris*), several strictly aquatic weeds, and various grasses and sedges. Tall indigo is kept under control when the fields are in rice, but is permitted to grow in abundance when the fields are not cropped, to help maintain the fertility of the land.

The same diseases and insects occur that attack rice in other parts of the State, but straighthead is more common and causes greater losses in the river district.

That portion of the State of Louisiana traversed by the Bayou Teche is generally referred to as the "Teche," or "Evangeline Country." The soils in this district and the crops grown, with few exceptions, are much the same as in the Mississippi River district. The soil is less porous than that along the river, but not so impervious as are the prairie soils. The method of irrigation is more like that followed on the prairies than that in use in the river district.

Until comparatively recent years the rice crop probably was grown as "Providence", or upland rice. Providence rice was grown on low areas enclosed by levees on the lower side to hold the water. Local rainfall was depended upon to supply the water required to mature the crop. On the more porous soils the crop was often grown in rows and cultivated to control weeds.

It is estimated that in the 5-year period 1932-36 an annual average of 8,000 acres was sown to rice in the Teche district. The preparation of levees and seedbed, the varieties, and seeding in the Teche district are similar to those in the Mississippi River district. Seeding, however, is begun later in the spring. The fields seldom are irrigated to induce germination. The irrigation water is obtained largely by pumping from Bayou Teche. The crop is largely cut by hand but is threshed and marketed in practically the same manner as on the prairies. The same weeds, diseases, and insects affect the crop as in the other rice-growing districts of the State.

WEEDS

Rice is grown under conditions that are very favorable for the growth of aquatic (water-loving) and semiaquatic weeds. If not eradicated promptly, such weeds increase rapidly and soon practically take possession of the fields, reduce yields, and detract from the value of the threshed product.

Weeds possess unusual vigor and usually produce an abundance of seeds, which often have the ability, under certain conditions, to lie dormant in the soil for years. Weeds are difficult to control, once they become established. The best method of control, therefore, is to prevent them from becoming established in the fields.

Weed seeds are spread by irrigation, drainage, floodwaters, wind, livestock, and machinery, and sowing foul seed. The spread of weeds is encouraged by permitting them to grow and produce seed on levees and ditch banks and in uncultivated corners of the fields. Weeds can be kept under control only by constant effort in preventing their propagation and spread.

The most common and troublesome weeds in the rice fields of the South are red rice (*Oryza sativa*), "curly indigo" (*Aeschynomene virginica*), "Mexican weed" (*Caperonia palustris* and probably other species), "tall indigo" (*Sesbania macrocarpa*), barnyard grass (*Echinochloa crusgalli*, and *E. colonum*), umbrella weeds or sedges (*Cyperus strigosus* and others), "nigger wool" (*Fimbristylis autumnalis*), "alligator head" (*Diodia teres*), "pongati" (seaweed) (*Sphenoclea zeylanica*), "day flower" (turtle back) (*Commelina virginica*), and smartweed (*Polygonum acre*).

Red rice is the most serious weed pest. Red rice belongs to the same species as white rice, and varieties having red kernels are extensively grown in some countries. It differs from white rice in having a red instead of the usual brown kernel coat. Red rice probably is as nutritious as white rice, but in most markets highly polished white rice is preferred by consumers. The chief objection to red rice is the fact that in milling rough rice containing some red grains, which often are smaller than those of the white, it is frequently necessary to mill so closely, in order to remove the red kernel coats, that considerable white rice is broken. The milled product has an unattractive appearance unless the red kernel coat is removed. The presence of red-streaked kernels in milled rice lowers its market value.

Red rice is spread largely, if not entirely, by using seed that contains red grains. Seed of the red rice variety, which is most troublesome in the Southern States, shatters readily, and the seed, like that of other weeds, has the ability to retain its viability for several years when buried in the soil. Unless eradicated promptly it soon practically takes possession of fields.

The common southern red rice variety can easily be distinguished from commercial rice by its sparse open drooping head (panicle), which has few grains on the branches. In growth it is more spreading than are the commercial varieties. Scattered plants in commercial fields can be pulled, but this is not practicable when red rice plants are numerous. The most effective control measure is to avoid seed containing red rice and thus prevent its introduction on clean land.

There is some natural crossing in rice, and because all the plants of the first hybrid generation and three-fourths of the second generation have the red kernel coat the proportion of red rice rapidly increases when crossing between red and white varieties occurs. The short-, medium-, and long-grain red-rice seeds and kernels, which are at times observed in rough and brown rice and in fields, probably originated as a result of natural crossing between the cultivated varieties of these types and red rice. Some of the red rice types that appear as a result of natural crossing are seemingly identical in all respects with the cultivated varieties except for the red kernel color. It is not possible to locate and pull these plants in fields.

Hand pulling, mowing, summer cultivation, and pasturing are the best means of controlling not only red rice but also curly indigo, tall indigo, Mexican weed, alligator head, barnyard grasses, umbrella weeds, and nigger wool when they are present in rice fields. Every precaution, however, should be taken to avoid introducing these and other weeds to clean land in the rice seed. The expense of hand-pulling weeds is prohibitive if they are fairly numerous.

DISEASES

There are several diseases that attack the rice plant in the Southern States, but only a few are of economic importance. Seedling blight, caused by the fungus *Sclerotium rolfsii* Sacc., attacks germinating seeds and young seedlings in warm moist weather before the root system is sufficiently developed to resist invasion. It is very destructive to germinating seeds and young seedlings that have emerged. The fungus destroys the tissues of the roots, and the seedlings fail to emerge or die after emerging. Early sown rice seems to be more subject to injury by this fungus than that sown late. This probably is due to the fact that conditions are more favorable for rapid germination and vigorous seedling growth late in the season; hence the rice seedlings are less subject to attack by the fungus.

Stem rot is caused by the fungus *Leptosphaeria salvinii* Catt. This fungus attacks the leaf sheaths of the plants, at the water line, when growing on submerged land. The small black spot on the leaf sheath enlarges, and eventually the tissues of the sheath and stem are largely destroyed and the affected plants may lodge. If the disease develops early it may prevent the plants from setting seed. In cases of severe infection, yields are materially reduced by failure of the plants to set seed or by lodging of the plants that have set seed. There is further loss due to difficulty in harvesting a crop that is lodged and the poor quality of the rice produced by lodged plants. The development of the disease and losses due to it may be checked by draining the water from fields about 6 weeks prior to maturity and then keeping the land wet but not submerged.

Leaf spot, due largely to infection by the fungi *Helminthosporium oryzae* V. B. de Haan, and *Cercospora oryzae* Miyake, causes a reduction in yields and in the quality of the rice produced. When plants are severely affected, the healthy leaf area is so materially reduced before the plants mature seed that the grain often is irregular in shape, light in weight, chalky, and of poor milling quality. Varieties differ in susceptibility to the leaf spot diseases, and the best control measure appears to be the use of resistant varieties.

Straighthead is a physiological disease and is not caused by any fungus or bacterial organism. As the name indicates, heads of affected plants remain erect and fail to set seed. Badly diseased plants may even fail to head. Plants affected with straighthead have leaves that are darker green and stiffer than normal, and they remain green after the normal plants have matured. The roots of affected plants are usually large and often fail to produce small branch roots and root hairs. The disease apparently is caused by organic materials that, in certain stages of decay, interfere with normal root development. The disease often can be controlled by draining the land about 4 to 6 weeks after it has been submerged and allowing it to dry out thoroughly before resubmerging.

The white tip disease apparently is associated with a shortage of iron in the plant. Plants affected have chlorotic white leaf areas and tips, twisted boots, stems, heads, and deformed seeds. In severely affected plants the heads often fail to emerge fully from the leaf sheaths. Yields often are reduced, and the quality of the rice pro-

duced is inferior to that of normal plants. Available information indicates that acidification of certain soils and the addition of organic matter to others have proved to be beneficial.

INSECTS²

The rice crop is relatively free from severe damage by insects, but each year they injure the yield and grain quality somewhat. The principal injurious insects are the rice stinkbug (*Solubea pugnax* (F.)), the rice water weevil (*Lissorhoptrus simplex* (Say)), stem borers, and the sugarcane beetle (*Euetheola rugiceps* (Lec.)).

By means of its long beak, the straw-colored, shield-shaped stinkbug sucks the milky juice from the rice kernel during its early development. The bugs may consume the entire contents of the kernel when in the milk stage, so that grain is not produced. When kernels in the dough stage are attacked, portions of the contents are extracted, leaving a chalky discolored area. Kernels so affected are called pecky rice. Molds often enter the punctures and cause black specks on the kernel, and these kernels often are broken in milling. Each year stinkbugs cause some reduction in yield and often affect adversely the quality of some of the rice produced in Arkansas, Louisiana, and Texas. Late-maturing varieties appear to be most severely attacked, as late in the season the bugs often are present in large numbers.

The rice water weevil in the larval stage is known as the rice root maggot. The maggots feed on the roots at the base of the rice plant. The roots may be pruned off, and in some cases even killed, and the development of the plants retarded. The extent of the injury to the crop as a result of root pruning appears to depend upon several factors. Information contained in Louisiana Agricultural Experiment Station Bulletin 214, Damage by Rice Water Weevil Proved Negligible, indicates that in Louisiana the injury to the crop is very slight, whereas in Arkansas the injury is apparently rather extensive, and according to Arkansas Agricultural Experiment Station Bulletin 299, the Rice Water Weevil, yields may be reduced as much as 30 percent.

Stems of rice plants are attacked by the larvae of the sugarcane moth borer (*Diatraea saccharalis* (F.)) and the rice stalk borer (*Chilo plejadellus* (Zincken)). The larvae (worms) bore into the stem and feed on the inner surface. This weakens the stalk, and often the head turns white, fails to bloom, and sets no seed after it emerges. The losses caused by borers are difficult to measure, but have been estimated at one bag of rice per acre. Varieties having large stems appear to be more susceptible to injury than those having small stems.

Although the sugarcane beetle is known in Louisiana principally as a pest of sugarcane, it is found injuring rice both before and after irrigation. This black, robust beetle gnaws the stem between the ground surface and the roots of the plant, usually causing it to wither and die. Many plants in a row are sometimes killed in this way. Rice plants growing on the levees may be injured throughout the season by this beetle.

² See Farmers' Bulletin 1543, Insects Injurious to the Rice Crop.

RICE MILLING

The kernel of rice as it leaves the thresher is enclosed by the hull or husk and is known as rough rice. A sack of rough rice weighs 180 to 225 pounds, a barrel of rough rice 162 pounds, and a bushel of rough rice 45 pounds. A crop of rice harvested with a binder yields about equal weights of rough rice and straw. The rough rice when milled yields about 63.9 percent of whole and broken kernels, 12.9 percent of bran, 3.7 percent of polish, and 19.5 percent of hulls. Rough rice is used for seed and also as feed for livestock, but most of it is sold to millers, who prepare it for market (fig. 20).

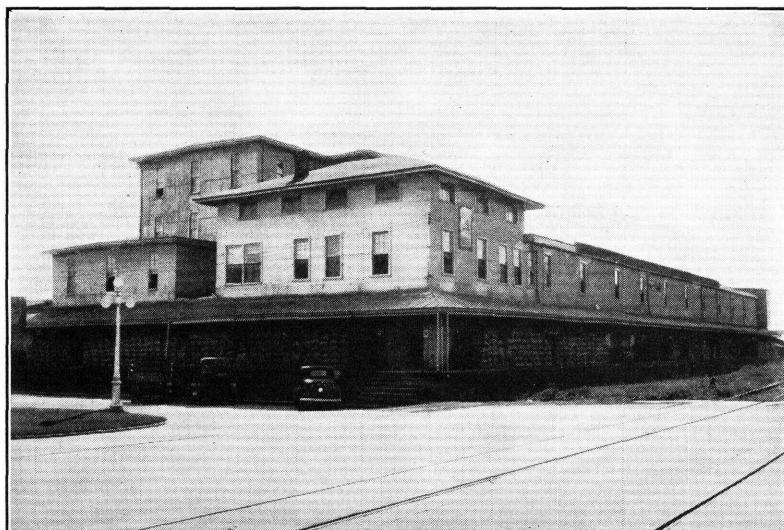


FIGURE 20.—A rice mill in which the rough rice is prepared for market.

In milling, the rough rice is first screened and fanned to remove trash, chaff, weed seeds, dried mud lumps, and light seeds. It then is conveyed to the hulling stones, which remove the hulls. From the hulling stones the mixture of hulled rice, rough rice, and hulls is fanned and passed to paddy machines, in which the rough rice is separated from the hulled kernels. The rough rice from the paddy machines is returned to the stones for removal of the hulls.

The hulled kernels, known as brown rice, are conveyed to hullers, in which a part of the bran layer on the outside of the kernels and most of the germ is removed by friction. It is then passed through a second set of hullers and in some mills to a pearling cone also. From the second hullers and from the pearling cone the rice is returned to the bran reel, for separation of the bran and rice. The rice is then conveyed to the brush, in which the kernels are polished.

In the polishing process more of the bran and some starch cells are rubbed off and are separated from the rice by means of screens. The light-brown powder forced through the screens is known as rice polish. After being polished, the rice is screened and conveyed to a revolving cylinder (trumble), where it is steamed, and if it is to

be coated with glucose and talc these materials are applied. The cleaned or milled rice is then separated into grades, weighed, and bagged.

UTILIZATION

The unbroken milled kernels are known as whole or head rice. This product commands the highest price and is sold under several grades established by the United States Department of Agriculture or under private classifications, which are based largely upon luster, color, and size of the kernels. Milled rice is largely used boiled, as a vegetable. However, it also is used as a breakfast food in the form of a cooked cereal, puffed rice, and rice flakes: and some rice flour is used.

The broken kernels are sold as "second heads," screenings, and brewers rice and are used as food, feed for livestock, in making fermented beverages, and as a source of starch and flour. Rice starch is used in cosmetics, in laundries, in confections, in the sizing and finishing of textiles, and can be used in making pastes, glues, adhesives, vinegar, acetone, and alcohol.

The bran consists of the kernel coats and the germ with varying quantities of hulls. Bran free from hulls is the most nutritious and palatable of the rice feeds. However, bran often becomes rancid if kept too long. The polish contains less fat and protein, but more starch than the bran. Bran and polish are used as concentrated feeds for livestock. Polish may also be used as food in the form of a thickening in gravies, in sauces, in puddings, as stuffing material in sausage, and in the manufacture of buttons, soap, and oil.

The hulls may be used for fuel, packing material, bedding for poultry, insulating material, soil mulch and fertilizer, and as a filler for horse collars. Hull ash is used as a bleaching agent, also as a filler for concrete and bricks, in making soaps and polishing and cleaning agents, and as a source of sodium silicate. Paper pulp and cellulose may be obtained from the hulls. The following products may be made from the cellulose: Cardboard, rayon, celluloid, and other plastics. Cellulose treated with sulphuric acid yields dextrin and glucose, which on fermentation produces ethyl alcohol. Cellulose treated with acetic acid forms cellulose acetate, from which artificial silk, films, nonshatterable glass, plastics, and rubber substitutes may be derived.

Rice straw is used for feed, and when the crop is cut and threshed by hand and the straw retains its original shape, as it often does in the Orient, it is used in making mats, sacks, sandals, brooms, hats, coats, rope, and is used as bedding for livestock, for thatching roofs, for making hedges to protect young plants, for fuel, and as a soil mulch and fertilizer. Rice straw may also be used in the manufacture of paper and cardboard and as a source of cellulose from which, as has already been indicated, many products may be derived.

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